WOLVES for YELLOWSTONE?

A REPORT TO THE UNITED STATES CONGRESS

VOLUME III **EXECUTIVE SUMMARY**

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WOLVES FOR YELLOWSTONE?

A Report to the United States Congress

Volume III Executive Summaries

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WOLVES FOR YELLOWSTONE?

A Report to the United States Congress

Volume III Executive Summaries

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National Park Service, Yellowstone National Park

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INTRODUCTION

The gray wolf (*Canis lupus*) was eliminated from Yellowstone National Park by the 1930's. Almost 50 years later, the gray wolf was listed as an endangered species. Under authority of the Endangered Species Act of 1973 as amended, recovery plans for the gray wolf in the northern Rocky Mountains were approved in 1980 and 1987.

The *Northern Rocky Mountain Wolf Recovery Plan* offers strategies for conserving wolves in 3 areas of the northern Rockies: northwestern Montana, central Idaho, and the Yellowstone area. In the first 2 areas, the plan projects that wolves would naturally recolonize. Wolves have been recolonizing northwestern Montana over the last decade, and there are persistent reports of wolves in Idaho.

Because of Yellowstone's geographic isolation from areas with established wolf populations, the recovery plan proposed establishing a wolf population in the Yellowstone area by reintroduction. That proposal raised a number of questions and concerns about the effects of restoring wolves to Yellowstone.

In 1988 the Senate-House Interior Appropriations Conference Committee appropriated funds for the National Park Service and the U.S. Fish and Wildlife Service to address 4 concerns about restoration of wolves to Yellowstone. The National Park Service and the U.S. Fish and Wildlife Service conducted the required investigations using extensive literature surveys, consulting experts from North America, Europe, and Asia, and independent investigations by university scientists. Wildlife agencies of Idaho, Montana, and Wyoming furnished data on populations and harvests of big game animals.

The summaries of the initial investigations were presented in *Wolves for Yellowstone? A Report to the United States Congress, Volume I, Executive Summaries*; with the complete manuscripts of the investigators being published in *Wolves for Yellowstone? A Report to the United States Congress, Volume II, Research and Analysis*--more than 600 pages of evaluation. Topics of these investigations included options for wolf management both inside and outside of Yellowstone National Park, the potential prey base for wolves in Yellowstone National Park, mathematical simulations of the effects of a restored wolf population on large ungulate populations, and estimation of the effects a wolf population may have on grizzly bears and other carnivores.

The National Park Service has continued to use National Park Service scientists, experts in the U.S. Fish and Wildlife Service, and scientists from various universities to investigate biological, sociological, historical, and economic questions about the establishment of a free-ranging population of gray wolves in Yellowstone National Park. Summaries of results of these investigations are presented in *Wolves for Yellowstone? A Report to the United States Congress, Volume III, Executive Summaries*; with the complete manuscripts of the investigators presented in *Wolves for Yellowstone? A Report to the United States Congress, Volume IV, Research and Analysis*.

Topics in these investigations include evaluation of all previous relocation and translocation of gray wolves in North America, further compilation of data about the prey base for wolves in and around Yellowstone National Park, and computer simulations of the potential effects of a restored wolf population on large ungulate populations both in and adjacent to Yellowstone National Park.

Several studies look at how wolves may interact with other system components; others provide estimates of the effects a wolf population may have on grizzly bears and other carnivores; while others examine the potential ecology of various wildlife diseases. The potential conflict between livestock and wolves outside Yellowstone National Park is a major concern. Abundance and distribution of livestock on the national forests adjacent to Yellowstone National Park is summarized and information on livestock depredations by wolves in North America is reviewed.

Other papers evaluate public attitudes on wolf reintroduction, the economic consequences of reestablishing wolves in Yellowstone National Park, and the paleontological and historical record of wolves in the area that has become Yellowstone National Park.

The conclusions and opinions expressed in these studies are those of the authors. They were asked to evaluate the potential effects of wolf reestablishment in Yellowstone in relation to certain aspects or attributes. They were not asked to evaluate the desirability of wolf recovery in Yellowstone.

Obviously, more questions can always be raised and may have merit. However, prediction of the future is an inexact science at best, as weather forecasts demonstrate on a daily basis. It is also becoming very apparent that the consequences of restoring a large carnivore will have profound but not disastrous effects; in fact, some of the most profound effects may be subtle changes in the interspecific relationships within a very complex community of organisms. Several investigators and other observers have already noted that if you want to know the precise effects of wolves in Yellowstone--put them in.

In 1991 the Senate-House Interior Appropriations Conference Committee appropriated funds and directed the U.S. Fish and Wildlife Service, in consultation with the National Park Service and the Forest Service, to prepare an Environmental Impact Statement on the reintroduction of gray wolves to Yellowstone National Park and central Idaho. A draft of the Environmental Impact Statement is to be completed within 18 months of the November 13, 1991, enactment of the Interior appropriation legislation. These investigations provide extremely valuable information to the responsible agencies who must conduct the evaluation of this important wildlife conservation issue.

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Manuscripts prepared by the individual authors were submitted for review by their peers in the respective fields during manuscript preparation and review. In addition, manuscripts were submitted for review by a core group of scientists in the National Park Service and U.S. Fish and Wildlife Service.

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HISTORICAL EVIDENCE

The Documentary Record of Wolves and Related Wildlife Species in the Yellowstone National Park Area Prior to 1882

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Executive Summary

A continuing question in the dialogues over wolf restoration in Yellowstone National Park, especially as that dialogue has been conducted in public forums, is whether or not wolves were native to the park area prior to the creation of the park in 1872.

Since early in this century, there has been disagreement among scientific investigators over the abundance of large mammals in the Yellowstone National Park area in the earliest historical period and in prehistoric times. This issue can to a great extent be resolved by a review of existing paleontological, archeological, and historical sources. This paper briefly summarizes the paleontological and archeoleological record, and conducts an exhaustive review of the historical record.

The historical record of early wildlife conditions in the Yellowstone National Park area, especially the period prior to about 1880, has been the subject of numerous reviews and interpretations since the 1920's. These previous analyses used no more than 25 early firsthand accounts of the park area, and reached two opposing conclusions. Some investigators were convinced that large mammals were rare, and others were equally persuaded that large mammals were abundant.

The present study is aimed at resolving this issue by examining many more accounts, and applying a more careful historical scholarship to the topic. We address the question of wolf presence in the earliest historical period in two ways. First, we examined the historical record for sightings and other evidence of wolves. Second, and of at least equal importance, we examined the historical record for evidence of sufficient prey base to support a wolf population. The wolf is generally recognized as having been widely distributed throughout the United States, and more particularly the Rocky Mountains, in prehistoric times, and so it is generally agreed among wolf authorities that if an adequate prey base, especially of large mammals, was present in the park area, then wolves would have been here exploiting those prey populations.

We present a summary and evaluation of 168 accounts of the Greater Yellowstone Ecosystem prior to 1882. Most of these accounts involve the park, and most are firsthand accounts of visits. Some are periodical accounts of the park, based on apparent firsthand observations provided by the periodical's sources. A few others are contemporary accounts, in travel guides and other published materials, in which the exact familiarity of the author with the park could not be precisely determined. In addition,

we provide reference to numerous photographs that provide evidence of animal presence.

Our conclusions were of two types, and are only summarized here from fuller versions at the conclusion of the complete paper. The first set of conclusions are historiographical; they were concerned with the nature and utility of the historical record as evidence. We concluded the following:

1. The more accounts consulted, the fuller the record of animals observed or reported becomes; even among members of a single visitor party, there were often dramatically different amounts of wildlife reported.

2. There were likewise great differences in animals observed between different parties visiting in the same year. This also strengthens our conviction that the historical record can be useful only if used as comprehensively as possible.

3. Large, noisy parties could and often did displace animals as they traveled, reducing their chances of observing the animals.

4. The behavior of animals, especially regarding whether or not they fled when approached by humans, was then, as it is now, widely variable.

5. Wildlife only slowly became a subject of primary interest to most visitors, who, in the 1870's, were in the park to see the area's famous geological and geothermal wonders. This complicates the use of these historical accounts as reflections of actual wildlife conditions.

6. The historical record as used by previous investigators, encompassing as it did only a handful of accounts, was too slight to allow more than general conclusions about the size of each species' population, and much too small to permit confident assertions that animals were not abundant.

7. Even our much larger historical source base only allows general statements about the abundance of most species, including the common ungulates.

Our second set of conclusions concerns what the historical record does tell us about wolves and other mammals in the period prior to 1882.

1. Wolves were present and were distributed throughout the Greater Yellowstone Ecosystem.

2. Other predators, including mountain lions, grizzly bears, black bears, wolverine, coyote, fox, and smaller mammals, were present and widely distributed.

3. Almost all observers (more than 90%) who commented on the abundance of wildlife expressed the belief that it was very abundant. Terms such as "hunter's paradise," and "plentiful game," were frequently employed by these early observers. Even those visitors who did not personally see much wildlife believed it was common, based on their observations of tracks and other evidence, and their contact with other visitors.

4. In the historical period before 1882, elk were distributed throughout the park area and the Greater Yellowstone Ecosystem. They were observed, sometimes in large herds, in all the areas where they would be expected today. Bighorn sheep may have been more common in some areas than they are today. Mule deer may have been more abundant than today, but were at least widespread. Bison were present in the park in several herds. Moose were common in the southern part of the park and in several other locations in Greater Yellowstone. White-tailed deer were never common in the present park area in this earliest historical period.

5. The Northern Range of Yellowstone National Park was winter range prior to 1882, apparently hosting large numbers of wintering animals as environmental conditions (winter snow depths, especially) allowed, just as it does today.

6. A variety of human activities, especially intensive skin-hunting, recreational hunting, subsistence hunting, poisoning of carcasses, and commercial trapping, appears to have dramatically affected animals in Yellowstone prior to 1882. These effects apparently included the near extermination of wolves from the park, a great reduction in beaver, and possible effects on other scavengers and predators. Effects on actual size and distribution of ungulate herds are difficult to determine or suggest.

In general, the historical record presented here allows us to reach a few decades further back into the park's ecological biography. It reveals that in the early 1800's, the park area was the home of large wildlife populations not too dissimilar from today's. The historical record does not allow us, however, to reach into some supposedly "pristine" period that can be used as a barometer of the health of the present park's ecological processes. Too many variables, including climatic factors and the changing role of Native Americans in the Greater Yellowstone Ecosystem, are in effect for any such simplistic comparison to be made.

A Review of Archeological and Paleontological Evidence for the Prehistoric Presence of Wolf and Related Prey Species in the northern and central Rockies Physiographic Provinces

Kenneth P. Cannon, United States Department of Interior, National Park Service, Midwest Archeological Center, Lincoln, Nebraska

Executive Summary

1. A study area of the northern and central Rocky Mountain Physiographic Province was defined and 36 archeological and paleontological sites within the area were selected for review.

2. The review consisted of prehistoric and historic deposits which span the last 25,000 years and contained significant faunal assemblages.

3. Gray wolf remains are documented from 10 dated prehistoric deposits in the study area. Evidence of wolves in the region begins about 12,000 years ago and continues into historic period. Prehistoric remains of wolves have also been recovered from deposits at Lamar Cave in Yellowstone National Park.

4. Elk are a persistent number of the regions faunal assemblage beginning about 10,000 years ago. Limited numbers in the faunal record may be the result of hunting and butchering practices, as opposed to their presence in the region.

5. Bison have also been a long-time member of the region's faunal assemblage. Bison have been recovered from Pleistocene through historic deposits. Limited numbers of bison from archeological sites in the mountains may be a result of the economic orientation of prehistoric groups occupying the higher altitudes.

6. Deer, bighorn sheep, and pronghorn are also present in significant numbers from the region's archeological and paleontological sites. Specific procurement patterns of these species in comparison to larger ungulates (bison and elk), may be factors reflecting the disparity on frequency between prehistoric and modern populations.

Are Wolves Native to Yellowstone National Park?

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Executive Summary

Available literature was perused to test the hypothesis that gray wolves were not residents of the Yellowstone National Park area prior to the arrival of humans of European descent. This hypothesis is based on the contention that wolves arrived in the area along with elk after being forced from lower elevations by human pressures. The following findings and conclusions resulted from this literature review.

1. Wolves were found to have occurred at several high elevation Holocene sites in Wyoming, Montana, and Idaho. This demonstrated that wolves can live at elevations similar to those in Yellowstone National Park.

2. Wolf remains were found in a Holocene site of approximately 1,000-1,200 years B.P. in the Lamar Valley in the north central part of the park. Elk remains were also found in the same paleontological site.

3. Wolves have very likely been part of the mammalian assemblage of Yellowstone National Park from at least 1,000 years B.P. to the time of their extirpation in the 1930's.

4. Based on the evidence from Lamar Cave, the hypothesis that wolves were not present in the Yellowstone National Park area prior to the advent of humans of European descent was refuted.

5. Wolves can realistically be considered part of the native fauna that existed in Yellowstone National Park prior to the arrival of Europeans.

SOCIOLOGY AND ECONOMICS

Identification and Documentation of Public Attitudes Toward Wolf Reintroduction in Yellowstone National Park

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Executive Summary

1. Nationwide data suggests the U.S. public likes the wolf; within the Rocky Mountain region 50% like the wolf while 30% dislike the animal. Visitors to the park also overwhelmingly support wolf reintroduction. In 1987, a statewide survey of the Wyoming general public (n = 371) randomly selected, revealed most Wyoming residents (48.5%) favored wolf reintroduction while 34% were opposed and 17% had no opinion.

2. Surveys were mailed to randomly selected residents of Montana and Idaho. The response rate for Montana was 61.2% (n = 672) and 57.2% (n = 618) for Idaho. The research instrument was divided into 4 sections: (1) attitude toward the wolf, (2) knowledge of the wolf, (3) willingness to reintroduce the animal, and (4) sociodemographic characteristics.

3. Eight attitudinal items were used to compute an attitude toward the wolf score. A score of 1.0 indicated a "strong dislike" of the wolf while a score of 5.0 indicated a "strong like" of the wolf. The Montana statewide general public received a mean score of 3.05 indicating an attitude of "neither like nor dislike" of the wolf (3.0). The Idaho statewide general public sample received a mean score of 3.31 indicating an attitude between "neither like nor dislike" of the wolf (3.0) and "like" of the wolf (4.0). The Wyoming statewide general public received a mean score of 3.15 indicating an attitude that also lies between "neither like nor dislike" of the wolf and "like" of the wolf.

4. Knowledge scores were also computed. All groups, the Wyoming statewide public, the Idaho statewide public, and the Montana statewide public, answered less than half of the knowledge items correctly. This indicates that much is still to be learned by the general public about the wolf. Results indicate that those respondents with higher knowledge about the wolf tend to have more positive attitudes toward the animal.

5. Most respondents from Wyoming, Montana, and Idaho stated they were in favor of wolf reintroduction in Yellowstone National Park. Most Montana residents (43.7%) were in favor of wolf reintroduction with 40.3% opposed and 16.0% having no opinion. Idaho residents supported wolf reintroduction significantly more than Montana residents with 56.0% in favor, 27% against, and 17% had no opinion. The Wyoming general public also supports wolf reintroduction (48.5%) with 34%

opposed and 17% no opinion. This research suggests that most residents of the 3-state region bordering Yellowstone National Park support reintroduction of the wolf into the park.

An Economic Analysis of Wolf Recovery in Yellowstone: Park Visitor Attitudes and Values

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Executive Summary

1. This study addresses the question of whether the benefits of wolf recovery in Yellowstone National Park (YNP) exceed the costs. The benefits of wolf recovery are the values that park visitors and others place on knowing that wolves are present in the Yellowstone ecosystem and on the opportunity to possibly see and hear wolves. Costs are associated with reduced populations of elk, deer, and moose which would affect viewing of animals in the park as well as hunting of animals migrating out of the park in fall and winter. Other costs are associated with livestock predation by wolves. The basic finding of this study is that the net social benefits for 20 years of wolf recovery in YNP are large and positive, on the order of $110 million.

2. This study also examines the impact of wolf recovery on the regional (Montana, Idaho, and Wyoming) economy. Sales of goods and services out of state and nonresident tourism expenditures in YNP and the adjoining states of Montana, Idaho, and Wyoming may increase by $19 million annually due to wolf recovery. This is because YNP visitation may increase by about 5% for out of region visitors. Increased nonresident tourism expenditure by YNP visitors will far outweigh an estimated total loss of $0.2 million per year in reduced nonresident hunting expenditures and reduced livestock exports. Using a simple export base model of regional economic development, this implies an annual positive net economic impact of $43 million for the regional economy. It is assumed that the impact of wolf recovery on other regional natural resource based industries is negligible.

3. The estimated benefits of wolf recovery to YNP visitors is based on the responses of 762 YNP visitors initially contacted at entrance stations in June 1991. A high response rate of 87% was achieved through 3 followup mail contacts with study participants. Based on the response to a hypothetical trust fund question, the typical respondent who favored wolf recovery would be willing to make a one-time donation of $23 for wolf recovery. Similar results were obtained for a separate sample of 612 YNP visitors surveyed in August-September 1990. About 1/3 of this value is associated with the recreational benefits of hearing or seeing wolves; the remainder is the existence value of knowing wolves are present in YNP. For YNP visitors opposed to wolf recovery, the typical respondent was willing to make a one-time donation of about $2 to prevent wolf recovery. The primary motivation for visitors opposed to wolf recovery was found to be expected reductions in hunting opportunities, which accounted for about 4/5 of the total expected donation.

4. There are about 2.8 million visits to YNP in the May-October summer season. Based on survey data corrected for oversampling of more frequent visitors, this implies a total of about 900,000 individual adult visitors who would participate in a wolf recovery trust fund and about 420,000 adult visitors who would participate in a trust fund opposing wolf recovery. The net social benefits of wolf recovery to park visitors at current visitation levels total $19 million in the first year and $118 million present value over 20 years. Assuming that the number of adult visitors is a known constant, the 90% confidence interval for the first year value is $14.8 to $23.6 million and $93 to $144 million for the 20-year present value. The donations in future years are based on one-time donations by first time YNP visitors who would not have been contacted in previous years. These values may be conservative by a factor of 3 given that individual values are based on typical (median) willingness to pay rather than mean (or average) willingness to pay. Additionally, possible net social benefits associated with increased YNP visitation are not included in this estimate.

5. Reduced hunter harvest of elk, mule deer, and moose in the Greater Yellowstone Area (GYA) due to wolf recovery could result in lost net social benefits on the order of $0.4 to $0.6 million per year or a present value of $2.9 to $4.7 million over 20 years. These estimates are probably high in that they are not adjusted for hunter use of substitute hunting opportunities. Average willingness to pay per hunter day for hunting districts adjoining YNP is derived from previous economic studies of Montana big game hunting. The hunter harvest of big game species on the Northern Yellowstone Range may be reduced by about 20% for elk, 14% for mule deer, and 30% for moose. If these reductions are primarily achieved through reductions in existing special permit hunts for antlerless animals, current big game populations on this range could remain at about current levels. The exception is that elk populations may be about 12% lower with wolves than without wolves. Elk hunter harvest may be reduced by about 20% for the Gallatin herd and 5% for the Sand Creek herd. It is assumed that reduction of hunter harvest of other types of big game due to wolf recovery would be negligible.

6. Expected impacts of wolves in the GYA on livestock are based on actual livestock losses in recent years in Alberta (population of 5,000 wolves), Minnesota (1,700 wolves), and northwest Montana (currently 40-50 wolves). All of these areas have programs for compensation of livestock owners for verifiable wolf kills. The average annual losses of livestock in these areas (inflated to 1991 dollars and corrected to full market value) are $97,600 in Alberta (for 1981-89), $50,830 in Minnesota (for 1979-91), and $2,682 in Northwest Montana (for 1987-91). Extrapolating these findings to a population of 150 wolves in YNP leads to estimated annual loss of $3,000 to $11,000 per year. The lost market value to livestock producers in the GYA is likely to be small because of the relatively small projected population of wolves, the separation of wolves from livestock concentrations, and because wolves will probably be managed as a nonessential experimental population. Animal damage control (ADC) costs for wolves are expected to be no more than $25,000 to

$40,000 per year based on ADC costs in Minnesota and the estimate that 15-25 wolves per year may disperse from a recovered YNP wolf population. These estimated costs assume that every wolf that disperses will be a problem wolf. In fact based on evidence from Alaska and Minnesota, wolves that disperse will suffer high mortality due to human causes.

7. About 70% of all respondents favor wolf recovery. There were significant differences in attitudes across population strata. Hunters were less likely to favor recovery than nonhunters; the same held for regional residents (Montana, Wyoming, and Idaho) compared to out of region visitors. About 82% of overnight visitor respondents said that they would prefer visiting the park with wolves reintroduced. This is similar to the findings of the only other survey of YNP visitors concerning attitudes of park visitors toward wolf recovery. The latter study sampled only overnight visitors and found that 86% felt that the presence of wolves would improve the YNP visitor's experience.

8. Multivariate statistical models were developed to see if the respondent reported willingness to pay for wolf recovery was consistent with economic theory. As one would expect, individual willingness to pay was significantly and positively correlated to income, previous familiarity with trust funds, measures of attitudes toward wildlife and the environment, and respondent reported measures of personal benefits from wolf recovery. As an example, the expected donation increases about 5% for every 10% increase in reported income. Similar consistency is shown in a model of willingness to pay for the subsample opposed to wolf recovery. These findings indicate that responses to the trust fund question are not random but are a predictable function of the respondents socioeconomic characteristics and attitudes. The general validity of willingness to pay measures derived from these types of survey techniques has been supported by actual cash transaction experiments for nonmarket goods such as access to public hunting areas.

9. The scope of this analysis is limited. While the costs of wolf recovery in the GYA in terms of possible reduced hunting and increased livestock predation are examined, benefit estimates are limited to those likely to be realized by park visitors. Benefits of wolf recovery to the 200 plus million U.S. residents who will not visit YNP in the next 20 years have not been estimated. Management costs of the wolf recovery program have not been estimated.

10. Assumptions regarding the biological and physical impacts of wolf recovery are required by the economic analysis. The assumptions used are based where possible on findings in *Wolves for Yellowstone?*. It is expected that 7-9 wolf packs with fixed territories could occupy Yellowstone's Northern Range; another 1-2 fixed packs could occupy the park's other winter ranges; and another 3-4 packs might be supported, but only if the latter were migratory. If each wolf pack plus loners averaged 10 wolves, this implies 110-150 wolves for YNP. Ten breeding pairs could

lead to these population levels in 10 years. Depending on the management of hunter harvests of big game in the GYA, a recovered population of up to 150 wolves is expected to reduce populations of most ungulate prey species, including elk, deer, moose, and bison by 20% or less. No species will become extinct in YNP due to wolf recovery.

MANAGEMENT OF WOLVES

Reintroductions and Translocations of Wolves in North America: An Analysis

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Executive Summary

1. Only 6 previous relocations of gray wolves have occurred. These have involved both captive-raised and wild-captured wolves. Three attempts have been made to reestablish wild populations of gray wolves, and 2 efforts have been made to resolve management problems by translocation of problem wolves. An intensive effort is in progress to reestablish red wolves of captive origin into certain areas of the southeastern United States by reintroduction.

2. Releases are broadly characterized as "hard" or "soft." Hard release refers to the immediate and direct release of wolves into a new environment. Soft release refers to the release of wolves into a temporary enclosure at the release site where they receive food and water, possibly live prey; are disturbed as little as possible; and generally given time to be calmed, monitored, and conditioned prior to release. Mating, denning, and whelping in the enclosure could be a part of the process. Gray wolf releases to date have been mostly hard releases; a soft release procedure is used with red wolves.

3. Captive-raised gray wolves that were socialized to humans approached humans after release, leading to their deaths. Use of captive-born wolves presents different problems than use of wild-captured wolves.

4. None of the adult gray wolves remained at their release site, but in no case was there a serious attempt to acclimate them to the release site by holding for an extended period (soft release). Released adult gray wolves have tended to travel extensively; most have attempted to return home; and a few have succeeded. Limited data suggest that gray wolves have difficulty homing if the distance they are moved is >64 km. Pups tended to become sedentary in the vicinity of the release sites. With the procedures used so far, even parents and offspring have tended to separate after release. Adult wild-captured wolves were able to kill ungulate prey in their new surroundings. Survival rates of adults and pups have been good.

5. Translocation of problem wolves was usually successful at arresting depredations by individuals. However, extensive post-release movements often brought individuals through areas where the potential for conflicts was high and they may have been attracted to livestock (possibly carrion) or to the type of habitat where they were originally captured.

6. An acclimation period of several weeks or months at the release site in a large enclosure will likely be necessary to overcome homing and extensive post-release movements of reintroduced gray wolves. Some of the procedures used in red wolf reintroductions appear to be applicable to gray wolves in the northern Rockies. Those procedures should be carefully evaluated for potential use.

7. Because of individual differences in wolf behavior and limited experience with wolf reintroductions, we should not expect reintroductions and translocations of wolves in the northern Rockies to proceed smoothly, particularly at first. Multiple releases over a period of years may be necessary to establish a viable population.

Taxonomy, Genetics, and Status of the Gray Wolf, *Canis lupus*, in Western North America: A Review

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Executive Summary

1. Early taxonomists named 24 subspecies of gray wolf (*Canis lupus*) in North America based on skull characteristics, body size, and color. The 24 subspecies were based largely on the work of E. A. Goldman and other taxonomists during the first half of the 20th century. These early taxonomists did not employ statistical analyses and, of course, did not have access to improved modern taxonomic methods. They had access to very few specimens from some areas, and some of the subspecies recognized were based on as few as 5 specimens. The naming of wolf subspecies occurred during a period in history when it was fashionable to name many subspecies.

2. Wolves vary in size, color, and in minor skull measurements within their vast geographic range. Except for color, these differences are minor, and when geographic differences in North American wolf populations have been shown, it was with the aid of extremely sensitive techniques, such as multivariate statistical methods. Most evaluations have shown little difference.

3. Wolves from different areas are not distinct in any one characteristic. Subspecific names usually represent only averages or trends that supposedly occur in a geographic area but almost universally intergrade over substantial distances with neighboring designations and there is usually considerable overlap between the characteristics of neighboring subspecies. Highly sensitive analyses usually are needed to distinguish differences in morphology of populations. Some specimens found well within the range of one named group may be practically identical to some specimens from the ranges of other named groups.

4. More recent taxonomic work using multivariate analysis and larger sample sizes suggests that this number of subspecies is unwarranted, with 5 North American subspecies possibly being more reasonable; yet the 24 named subspecies persist in the literature.

5. Genetic studies of wolves using molecular techniques suggest genetic differentiation among North American populations too small to justify many subspecies. Genetic mixing of all but geographically isolated wolf populations is facilitated by genetic

exchange among local and distant populations through dispersal and colonization of new areas. Dispersal (implying gene flow) over large distances has been documented for wolves, including across multiple alleged subspecific ranges. Therefore, genetic divergence among even widely separated populations is limited.

6. Wolves were essentially eradicated in the Rocky Mountains south of central Canada by the 1930's, and thus any characteristics peculiar to the populations in that area of the continent were lost. Since then wolves most likely from Alberta and British Columbia (B.C.) began appearing in the northwestern U.S., and within the past decade established a breeding population.

7. Evidently no populations of wolves remained in the area of western North America ascribed to *C. l. irremotus*, including Yellowstone and central Idaho, by about 1930. By 1940 wolves had been eliminated from nearly the entire western half of the U.S., and for some 700 km northward into Canadian provinces in the lower elevation settled areas. From the 1930's to the 1950's the wolf recolonized much of southwestern Canada but was again intensively controlled and the expansion stopped. Since that time populations in Alberta and B.C. have continued to colonize southward, reoccupying much of the southern parts of the provinces, with the exception of the prairie biome, and a wolf population has begun recolonizing northwestern Montana and possibly Idaho and Washington. Increased wolf observations in the early 1950's and the mid- to late-1970's corresponded to increased wolf numbers and range expansion in Alberta and B.C. A pattern of sporadic, yet persistent reports, with an occasional wolf killed, persisted throughout western Montana, northern and central Idaho; in northwestern Wyoming infrequent reports persisted but no specimens were recorded. No persuasive evidence of reproduction was obtained from 1940 to 1986 in the western U.S. This would be consistent with very low wolf numbers, probably individuals dispersing from Canada possibly supplemented by occasional reproduction.

8. It is significant that skulls of wolves examined that have been killed in the northwestern U.S. from 1941 to 1991, including the wolf from central Idaho in 1991, fall within the morphological grouping of wolves from Canada. First, it shows that wolves dispersing from packs probably several hundred kilometers away were reaching the northwestern U.S. during that era. Second, it strongly suggests that no "original" wolves were left in the northern Rockies of the U.S. One specimen killed in the area that resembled *C. l. irremotus* was killed a few kilometers north of Yellowstone National Park in 1988. This individual was killed close to a captive colony of wolves, the founders of which were from central Montana, and showed characteristics of captive rearing.

9. The subspecies of wolf that was described for the central Rocky Mountains, *C. l. irremotus*, was similar to other subspecies, especially those in the western U.S. and extreme southwestern Canada. Wolf populations that occurred in the northwestern

U.S. and extreme southwestern Canada prior to eradication may be assignable to a "supergroup" that was distinguishable from another "supergroup" occupying most of Canada and interior Alaska.

10. The taxonomy of the gray wolf in North America is in need of revision. Very possibly, there should never have been a *C. l. irremotus* named, as any difference between it and neighboring North American subspecies is small. The most recent thinking on subspecific differentiation of North American wolves, from a morphometric standpoint, suggests that approximately 5 subspecies might be appropriate, with affinities occurring mainly in an east-west direction and a pronounced character change in the area just north of the border between Canada and the U.S. This would be consistent with the current trend in taxonomy, which is to combine subspecies where there is no appreciable genetic difference and no evidence of geographic or behavioral isolation.

11. From the 17th through the 19th century, wolves in North America received an ecological jolt of epic proportions, perhaps akin to that of the Pleistocene but occurring in a mere 300 years. From about 1870 to 1920, a span of 50 years, wolves west of the Mississippi went from universally distributed robust populations to extermination. Whatever the genetic relationships of those original wolves to the remainder of the species, they are gone. Someday we may be able to reconstruct a better understanding of what the mosaic of variation was among wolves in western North America. Perhaps, as technology advances in analysis of genetic variation, aspects of this dimension can be reconstructed from preserved specimens.

12. Historic patterns of variation in wolves have not been static, but dynamic, with glaciation and human-related extirpation being major influences. There are areas of North America where in recent times a subspecies was recognized, was extirpated, and the area was recolonized by wolves from the area of another recognized subspecies. Primarily, this occurred on islands and peninsulas where the probability of animal extinctions is known to be higher. Wolves are recolonizing northwestern Montana from another area, west central Canada. Any "original" wolves that have managed to survive in the northwestern U.S. will interbreed with those from more northerly stock. If any individual or small relict population of *C. l. irremotus* stock could have managed to survive, it would probably be suffering some loss of genetic variability due to small population size. The "original stock" undoubtedly was a dynamic entity with long distance dispersal in and out of the area and with local extinctions and recolonizations. We need to dismiss the typological thinking of local types and recognize that local extinctions and recolonization from distant areas occurs constantly in nature. It is the rule, not the exception.

13. In view of the information presented above, we conclude that if *Canis lupus* is to be recovered in the western U.S. it <u>is appropriate</u> to reintroduce wolves to the Yellowstone area. If taken from southwestern Canada, reintroduced wolves will be

of the same genetic stock from which natural dispersers no doubt immigrated into the original Yellowstone population, the same stock as those currently recolonizing Montana and Idaho, and the same stock that, given enough time, may get to Yellowstone without human help.

14. Indications are that wolves of current southwest Canadian stock will continue to expand their range southward and reproduce in the northwestern U.S. Given enough time they will likely become established in the Yellowstone area. Therefore, obtaining wolves from southern British Columbia or Alberta for reintroduction into Yellowstone and/or central Idaho would only accelerate an ongoing process and need not be viewed as compromising the "natural" or "historic" taxonomic arrangement of wolves in the area.

UNGULATE PREY BASE AND EFFECTS OF WOLF RESTORATION

Population Models for Elk, Mule Deer, and Moose on Yellowstone's Northern Winter Range

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Executive Summary

1. With recent developments on the proposed wolf reintroduction in Yellowstone National Park, a need has arisen for estimating elk, mule deer, and moose numbers on Yellowstone's Northern Winter Range. We developed population models for these ungulates using harvest, mortality, and classification data in a PC-based software program, POP-II. Advantages of using POP-II are (1) it is relatively inexpensive, (2) it utilizes existing population trend and harvest data, and (3) it operates on a personal computer.

2. Apart from existing, provisional, sightability model estimates, we produced a second population estimate for Northern Range elk. Our estimates showed the elk population continually increased during the 1970's to a peak of about 21,000 animals in winter 1987-88. The population then declined to about 17,000 elk in winter 1989-90.

3. We produced first-time population estimates for Northern Range mule deer. We estimated the mule deer population increased during the mid-1970's to a peak of about 3,300 in late winter 1987-88. The mule deer population then declined to about 2,600 in late winter 1989-90.

4. We produced a first-time population model for Northern Range moose. Our estimates show the Northern Range moose population slowly increased from approximately 366 animals in winter 1975-76 to 432 in winter 1989-90.

5. POP-II models are flexible and can be easily updated so managers can vary mortality and recruitment according to several scenarios and predict the possible outcomes to the population in question. Using the POP-II models we described, wildlife managers can predict what effects hunter harvests, reproduction, and additional mortality (i.e. wolf predation) may have on elk, mule deer, and moose populations inhabiting Yellowstone's Northern Range.

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Predicted Effects of Wolf Predation on Northern Range Elk, Mule Deer, and Moose Using POP-II Models

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Executive Summary

1. Elk, mule deer, and moose population models were used to predict some effects a wolf reintroduction in Yellowstone National Park (YNP) may have on these 3 ungulate populations associated with Yellowstone's Northern Winter Range. We evaluated the effects of wolf predation plus observed human harvests on elk, mule deer, and moose. We also estimated the effects of wolf predation and lowered human harvests on the 3 big game species.

2. For 78 or 100 wolves inhabiting the Northern Range, our models suggested the antlerless elk harvest would have to be reduced 27% to allow for an increasing elk population. Likewise, antlerless mule deer and antlerless moose harvests would have to be reduced 50% or eliminated to sustain a recovered wolf population and maintain mule deer and moose populations above or near present levels.

3. Our models did not include functional and density-dependent predator-prey responses. We did not speculate on how or to what degree these predator-prey responses may occur, but if they did, Northern Range ungulate populations may be larger than we estimated and hunter opportunities and harvests may not be affected to the degree proposed in our models. Our estimates concerning the effects of wolf predation on Northern Range mule deer may be inaccurate because observed data are lacking for this species. However, if wolves establish on Yellowstone's Northern Range, we recommend a conservative antlerless deer harvest, at least until more mule deer population data can be gathered and analyzed for this herd. Existing population data were limited for our provisional moose model. We suggest obtaining better information on moose to more accurately estimate wolf predation effects on this population.

4. To investigate wolf effects on elk, mule deer, and moose, we assumed 12 wolves were hypothetically reintroduced in YNP in 1980 and the modeled wolf population rapidly increased. Two wolf population models, having either a maximum of 78 or 100 wolves, were used to determine a range of effects on the ungulate populations. Each wolf population was limited to Yellowstone's Northern Range and preyed only on wild ungulates.

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5. For each wolf population, we used 3 scenarios, having different wolf predation rates (9, 12, and 15 ungulates/wolf/year), to predict the range of effects wolf predation may have had on elk, mule deer, and moose during the 1980's. We estimated numbers of elk, mule deer, and moose killed by wolves according to relative ungulate abundance, ungulate vulnerability to wolf predation, and age/sex class (young, females, and males) vulnerability to wolf predation.

6. For elk, we developed 2 population models, a Prefire Scenario and a Postfire Scenario. The Prefire Scenario ran from 1975-89 and estimated elk numbers using observed elk classification and hunter harvest data. During the 1980's, high antlerless elk harvests were used to reduce the Northern Range elk population, but even with these antlerless harvests, we estimated the Prefire Scenario elk population increased from 16,000 in 1980 to 21,000 in winter 1987-88 and then, because of the severe drought, fires, and high hunter harvest in 1988, declined to about 17,000 in 1989. The Postfire Scenario ran from 1975 to 1994. We incorporated into this model the positive reproductive benefits the 1988 fires were expected to have on the elk population. The model used observed harvest and classification data for years 1975-89. Average hunter harvest data from the late 1980's was used for the 1990-94 harvests. Compared to reproduction observed in the late 1980's, higher reproduction (26-36 calves/100 cows) was used for 1990-94. Postfire Scenario elk population estimates were the same as the Prefire Scenario up to 1989. For the Postfire Scenario elk numbers increased from about 17,000 in 1990 to 21,000 in 1994.

7. Our mule deer and moose models, without wolves, used observed hunter harvest and classification data to estimate population numbers from 1975-89. During the 1980's, we estimated mule deer increased to about 3,200 in 1988 and then declined to 2,600 in 1989. Throughout the 1980's we estimated the moose population remained stable or increased slightly to about 400 animals.

8. The Northern Range elk population appeared unable to sustain 78 wolves and the observed hunter harvests of the 1980's. Using observed hunter harvests, Prefire Scenario elk numbers were 27-43% smaller in 1989 with 78 wolves than when wolves were absent. With 78 wolves and the human antlerless elk harvests reduced 27%, the estimated elk population was 5-18% smaller in 1989 compared to the elk population without wolves.

9. The Northern Range elk population also could not sustain 100 wolves and the observed hunter harvests of the 1980's. With observed hunter harvests and 100 wolves, Prefire Scenario elk numbers were 31-51% smaller in 1989 compared to the elk population without wolves. When the human antlerless elk harvests were reduced 27%, the estimated elk population was 11-30% smaller compared to population estimates without wolves.

10. With 78 wolves and the human antlerless elk harvests reduced 27%, Postfire Scenario elk population estimates were 5% (20,287 elk) to 41% (12,561 elk) lower in 1994 than population estimates without wolves. With 100 wolves and the antlerless elk harvests reduced 27%, the estimated elk population increased to about 17,000 under the first wolf-predation-rate scenario of 9 ungulates/wolf/year, remained relatively stable at about 14,000 elk under the second scenario of 12 ungulates/wolf/year, and rapidly declined in the 1990's under the third scenario of 15 ungulates/wolf/year.

11. The only condition in which our modeled mule deer population was able to support wolf predation under the 3 predation rate scenarios was when the human antlerless harvest was eliminated. For these wolf predation and hunter harvest scenarios, the modeled mule deer population ranged from 0 to 36% larger in 1989 compared to the deer population estimates with observed hunter harvests and no wolf predation.

12. The modeled moose population could not sustain observed human harvests of the 1980's and wolf predation. For 78 wolves and human bull and cow moose harvests reduced 50%, the modeled moose population was 5% smaller to 12% larger compared to moose population estimates without wolves. Using the same reduced moose harvests and having 100 wolves, the moose population estimates ranged from 13% smaller to 7% larger compared to no wolf predation. When the high bull harvests of the 1980's were maintained in our models but the cow harvests were eliminated, the modeled moose populations with wolf predation were nearly the same as moose population estimates having wolf predation and observed hunter harvests reduced 50%.

Wolves in Yellowstone, Jackson Hole, and the North Fork of the Shoshone River: Simulating Ungulate Consequences of Wolf Recovery

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Executive Summary

This report summarizes the results of an expansion of the wolf-ungulate simulation model for Yellowstone National Park, conducted by M. S. Boyce in 1990, to encompass Jackson Hole and areas along the North Fork of the Shoshone River in northwestern Wyoming. In addition, the revised program enlists some new mathematical structures, e.g., a different functional response. The following conclusions may be reached based upon the behavior of this spatially explicit computer model:

1. Expanding the model to encompass areas outside the park has the effect of stabilizing fluctuations in wolf and ungulate numbers, and increasing the probability for long-term persistence of a wolf population.

2. A revised functional response equation has the effect of increasing the consequences of wolf predation on moose and mule deer wintering in Yellowstone National Park. Yet, as in the original model, there is no combination of management choices where wolf predation has devastating consequences to ungulate populations in the Greater Yellowstone Ecosystem.

3. Wolf predation under the most likely default assumptions is predicted to cause a reduction in the number of elk, bison, mule deer, and moose in the Greater Yellowstone Ecosystem. Mean elk numbers may be expected to be 5-20% lower if wolf recovery is accomplished. Fewer bison are expected to be killed by wolves, but the proportionate consequences to population size may be comparable to the effect of predation on elk. Moose and mule deer may be affected even more than elk in certain localities. We assume that wolves will have minor consequences to other vertebrates including bighorn sheep and pronghorns.

4. Wolf recovery in the Greater Yellowstone Ecosystem is not contingent upon discontinuing hunting for ungulates in areas near the parks. However, continued hunting when combined with wolf recovery will result in smaller ungulate populations. Elimination of elk hunting is not viewed as a viable option in Jackson Hole because of winter feeding programs which nearly eliminate over-winter mortality. Reduced moose hunting in Montana may be necessary to sustain wintering moose populations on the Northern Range.

5. Wolf recovery should reduce the need to cull elk in Grand Teton National Park.

6. Wolf numbers are expected to fluctuate substantially, but should eventually reach 50-170 animals, with population size largely depending upon management actions outside of the parks. Wolf populations along the North Fork of the Shoshone River may not be secure, but are expected to be quickly repopulated by dispersers from Yellowstone should they be locally extirpated.

7. To refine predictions of the model, research is needed to obtain detailed information on plant-herbivore dynamics, moose and deer populations, seasonal dynamics, and the functional response of wolf predation. Implementation of wolf recovery should be accompanied by a carefully designed monitoring program.

Estimating the Size of the Northern Yellowstone Elk Herd from Fixed-wing Aircraft and Helicopter Surveys--A Progress Report

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Edward O. Garton, Department of Fish and Wildlife, University of Idaho, Moscow, Idaho 83843

Executive Summary

1. Recent studies in western North America suggest visibility of elk is only 0.59-0.66 during aerial surveys. Therefore, population models of the predicted effects of a wolf recovery into Yellowstone National Park based upon uncorrected counts may provide biased prediction of wolf effects. The purpose of this investigation was to estimate the numbers of elk actually missed during aerial counts and to compare the efficiency of fixed-wing versus helicopter counts.

2. Helicopter surveys were 7% more efficient for observing elk than were fixed-wing surveys. The probability of detecting radiocollared elk was 0.75 during early winter and 0.50 during late winter from fixed-wing aircraft. The probability of detection from helicopter was 0.83 during early winter and 0.70 during late winter.

3. Sightability of elk from aircraft in Yellowstone's Northern Range was the highest yet reported from the western United States, apparently because of the extensive open grasslands and large concentrations of elk.

4. Multivariate step-wise logistic regression analysis of sightability variables is yet to be completed. A final report is expected during the fall of 1992.

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Potential Impacts of Yellowstone Wolves on Clarks Fork Elk Herd

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Executive Summary

1. Simulation modelling implies that approximately 3 wolf packs would occupy the summer range of the Clarks Fork elk herd within Yellowstone National Park (YNP).

2. These packs could remain resident within YNP or become migratory moving outside of YNP to occupy the winter range of the Clarks Fork elk herd during winter.

3. The simulated elk population remained stable under the combined influence of wolf predation and hunter harvest at current levels.

4. A resident wolf population would reduce numbers and annual harvest of the Clarks Fork elk herd by approximately 3%.

5. A migratory wolf population would reduce numbers and annual harvest of the Clarks Fork elk herd by approximately 15%.

INTERACTIONS WITH OTHER ECOSYSTEM COMPONENTS

Livestock Grazing on National Forests and National Parks Within the Greater Yellowstone Area

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Executive Summary

1. The location, size, distribution, numbers and type of livestock, and grazing season were compiled and evaluated for the 1991 grazing season for livestock grazing allotments on Grand Teton National Park and national forests adjacent to Yellowstone National Park (YNP). Both Geographical Information System and descriptive data sets were developed for managers to use in defining livestock grazing programs or evaluating alternatives regarding wolf management.

2. Of 440 grazing allotments, 392 (89%) are active and they comprise 16,531 km^2 (45%) of the total national forest area of approximately 36,825 km^2. Fifty percent of all allotments were on the Bridger-Teton and Targhee National Forests.

3. A total of 77,362 cattle, 105,051 sheep, and 1,272 horses were authorized for grazing on national forests and Grand Teton National Park. Forty-two percent of the cattle were grazed on the Bridger-Teton National Forest and 49% of the sheep were grazed on the Targhee National Forest. The Bridger-Teton and Targhee National Forests account for 90% of all sheep grazed in the Yellowstone area.

4. Livestock were authorized to graze on allotments an average of 98 days, varying from 84 to 129 days. Median dates livestock were allowed on national forest allotments ranged from 25 June to 1 July. Median dates livestock were removed from allotments ranged from 15 September to 25 October. For most national forests, livestock were removed from allotments during the second or third week in October.

5. Nearly all active grazing allotments are not adjacent to the YNP boundary. Livestock grazing occurs closest to YNP on the northwestern and southwestern corners of the park. Grazing allotments are most distant from the north, east, and south boundaries of YNP. Allotments ranged from 0 to 59.7 km and averaged from 16.6 to 36.2 km from the park boundary in the 4 cardinal directions (north, east, south, and west).

6. Large areas within the study area, including Yellowstone and Grand Teton National Parks, have no domestic livestock grazing and comprise approximately 30,659 km^2.

A Review of Wolf Depredation on Livestock and Implications for the Yellowstone Area

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Executive Summary

1. We summarized data regarding wolf depredation on domestic livestock in northwestern Montana, Minnesota, and Alberta and British Columbia, Canada. Data collected (for as many as 17 years) included number of cattle and sheep (young and adults) verified as wolf depredations, livestock numbers in wolf range, and wolf population numbers. We attempted to use this data to develop predictive models of livestock losses on public lands surrounding Yellowstone National Park.

2. Calves comprised between 68% and 85% of wolf depredation on cattle, possibly because they are smaller than adults. Annual depredation on cattle averaged 4 adults and 23 calves in Minnesota, 76 adults and 159 calves in Alberta, and 44 adults and 93 calves in British Columbia. In northwestern Montana, wolf depredation averaged 3 cattle annually. Annual wolf depredation rates (losses/1,000 livestock available) on cattle averaged 0.12/1,000 in Minnesota, 0.87/1,000 in Alberta, 0.23/1,000 in British Columbia, and 0.04/1,000 in northwestern Montana.

3. Wolf depredation on sheep annually averaged 50 in Minnesota, 33 in Alberta, and 26 in British Columbia. An average of 2 sheep were lost to wolves annually in northwestern Montana. For the data provided, wolves did not select for lambs over adult sheep in depredation situations. Sheep losses versus sheep available to wolf depredation averaged 2.37/1,000 in Minnesota and 0.54/1,000 in British Columbia and averaged 5-10 times higher than for cattle. We could not calculate sheep depredation rates in Alberta because we could not obtain estimates of sheep numbers in wolf range. In northwestern Montana, wolf depredation on sheep averaged 0.21/1,000 available.

4. Wolf numbers in Minnesota, Alberta, and British Columbia are several times larger than what others believe could inhabit Yellowstone National Park or the surrounding area. Larger wolf populations may have more individuals preying on livestock. In most areas where wolves and livestock live together, wolf numbers were unavailable or crudely estimated, and we were unable to investigate whether livestock losses were related to wolf numbers. In one small experimental study area (152 km^2) on the Simonette River in Alberta, wolf numbers were accurately known but too few years data existed to predict a relationship between wolf numbers and livestock

losses (additionally, wolf control was not conducted during the first 4 of this 6 year study).

5. Using data from Minnesota, we found no significant relationships between cattle or sheep losses and their respective availability. Cattle and sheep losses were also not related to total land area of farms within wolf range. Lack of a significant loss-availability relationship for the Minnesota data may suggest that depredation rates (losses/1,000 available) from other areas should not be used to predict numbers of possible livestock losses on public lands in the Yellowstone area. However, the data do suggest livestock losses will likely be relatively low on a large scale.

6. Wolf control in northwestern Montana, Minnesota, Alberta, and British Columbia likely contributed to the relatively low incidence of wolf depredation on livestock. However, individual livestock producers may experience persistent or large losses and these potential losses support having responsive and effective wolf control strategies.

7. In addition to lethal control measures, wolf control plans can include non-lethal strategies such as improved animal husbandry or livestock guarding dogs (although guarding dog effectiveness may be limited in deterring wolf depredations). From our review, wolf depredation on livestock was highly variable both among years and among areas experiencing depredations. Wolf control and improved animal husbandry can both work directly and indirectly in reducing the incidence of wolf depredation on livestock.

The Potential Role of Rabies in Relation to Possible Yellowstone Wolf Populations

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Executive Summary

1. Rabies in wolves was of significant concern in Europe during the seventeenth and eighteenth centuries. Rabid wolves have been significantly more abundant in Europe than in North America.

2. In the United States, prior to the late 1950's, rabies was predominantly a disease of domestic animals with dogs as the primary carriers. Since the late 1950's, when rabies control programs were established, rabies has decreased in dogs, cats, horses, cattle, and humans, and has steadily increased in wildlife.

3. Less than 1 person per year is infected with rabies within the United States and Canada.

4. In the United States and Canada, the predominant wildlife species infected with rabies are those which are primary carriers. The skunk, raccoon, bat, and fox comprise 98% of reported rabies cases in wildlife.

5. In North America, there are 5 distinct strains of terrestrial rabies. Each strain is specialized for a particular host and each strain can be distinguished from the others using laboratory techniques with monoclonal antibodies. Associated with each of these 5 strains are 5 outbreaks (expanding areas) of rabies currently in the United States and Canada. The 5 principal outbreaks in the United States and Canada are:

   A. Skunk rabies in northcentral states, southcentral Canada, and California.
   B. Skunk rabies in southcentral states.
   C. Raccoon rabies in mid-Atlantic and southeastern states.
   D. Arctic fox rabies in Alaska, Northwest Territories, and southeastern Canada.
   E. Gray fox rabies in a small area of Arizona.

6. Idaho essentially has no terrestrial rabies, only bat rabies. All wildlife rabies cases in Idaho have been in bats.

7. In Montana and Wyoming, skunk rabies is enzootic. Skunks comprise over 50% of rabies cases. All other animals are infected as "spillover" from exposure to skunks.

8. In Alaska, where the fox strain of rabies is enzootic, 4 wolves, from an estimated population of 6,000 to 8,000 wolves, have been reported with rabies in the last 5

years. In Minnesota, where the skunk strain of rabies is enzootic, no free-ranging wolves, from an estimated population of 1,700 wolves, have been reported with rabies.

9. Rabies has never been diagnosed in Yellowstone National Park.

10. Since skunk rabies occurs in areas where skunk densities are high, it is extremely unlikely that rabies will extend into Yellowstone National Park where skunk densities are very low.

11. North American wolves and coyotes are not primary carriers of rabies and therefore do not play a significant role in the spread of rabies and infrequently become infected with rabies.

12. The addition of the wolf to the Greater Yellowstone Area would not contribute any additional risks associated with rabies to humans, livestock, or wildlife.

The Disease Ecology of Brucellosis and Tuberculosis in Potential Relationship to Yellowstone Wolf Populations

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Executive Summary

Brucellosis (*Brucella spp.*)

1. Wild canids, such as foxes, coyotes, and wolves can be naturally infected with bovine brucellosis (*B. abortus*), rangiferine brucellosis (*B. suis*, biovar 4), and possibly canine brucellosis (*B. canis*).

2. Wild canids become infected with brucellosis from eating abortion or calving materials, such as fetuses or fetal membranes, from infected primary hosts such as cattle, bison, or reindeer.

3. In general, wild canids do not become clinically ill due to *Brucella* infections. Reproductive disorders in wild canids due to brucellosis are rarely observed.

4. Wild canids can shed *Brucella* bacteria if enough infected material is originally ingested. Bacteria are shed in very low numbers, often in lower numbers than the infective dose for cattle.

5. Wild canids may be considered to be mechanical vectors (which only transport the disease for a limited time from one place to another), rather than biological vectors (which grow, maintain, and shed organisms in greater numbers than which it was originally infected).

6. In large undeveloped areas, such as national parks, wild canids may actually play a positive role in the disease ecology of brucellosis. By ingesting *Brucella*-infected material, especially during calving season, and excreting less bacteria than they eat, canids would reduce the amount of abortion or calving material capable of infecting other bison or elk.

Tuberculosis (*Mycobacterium spp.*)

7. The 3 principal types of tuberculosis affecting wildlife are *M. tuberculosis*, *M. bovis*, and *M. avium* complex.

8. Tuberculosis in humans and domestic animals in industrialized countries has been almost eradicated. The predominant reservoirs of this disease are now captive exotic

and North American wildlife especially in primate colonies, game farms, and zoological parks.

9. Tuberculosis in wildlife is difficult to diagnose due to a lack of test methods validated for wildlife. Necropsy is the most reliable method when complimented with histopathology and bacterial cultures.

10. Canids, including foxes, coyotes, and wolves, can be infected with tuberculosis. The disease in canids is similar to that in other animals.

11. Free-ranging canids are rarely reported with tuberculosis due to limited exposure that canids have to tuberculosis, limited investigations, and lack of proven diagnostic methods.

12. Wild canids do not act as reservoirs of tuberculosis. Tuberculosis is not a population limiting factor for canids.

Spring Bear Use of Ungulates in the Firehole River Drainage of Yellowstone National Park

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Executive Summary

1. The Interagency Grizzly Bear Study Team studied spring bear use of ungulates in the Firehole River drainage, 1985-90. Data were collected from a total of 646 ungulate carcasses concerning location, species, sex-age cohort, and bear use. These data could serve as a basis for a comparative study after wolf establishment or reintroduction, to determine relationships among wolves, ungulates, and bears on the Firehole winter range.

2. Between 6 and 401 ungulate carcasses were found annually on transect routes. Mortality of adult elk varied most and mortality of adult bison least among years. Most mortality occurred between Julian dates (JD) 60 and 104, with bison mortality more prolonged than elk mortality. Most (44-75%) ungulate mortality was judged to be from under-nutrition and disease. Both coyote and bear predations were infrequent.

3. Bears made proportionally heaviest use of ungulates that died between JD 60 and 104; in areas greater than 5 km from the Old Faithful development and greater than 400 m from the Norris Junction-Old Faithful road; and within 50 m of the forest-nonforest edge, especially near human facilities. Adult female bison were the most heavily scavenged ungulate species and sex-age cohort by bears. Frequency of carcass use by grizzly bears on transect routes reached a maximum when greater than or equal to 100 carcasses were available. This number was exceeded only 1 of the 6 study years, during 1989.

4. Only 9% of bear track sets found were made by black bears. Of the grizzly bear track sets, 82% were in the range of adult females and subadult and adult males. Density of grizzly bear track sets peaked between JD 90 and 104, while density of black bear track sets peaked after JD 119. We were ca. 17x as likely to find grizzly bear track sets greater than compared to less than or equal to 5 km from the Old Faithful development.

5. Reintroduced or established wolves could affect bear use of carcasses by (1) effects on ungulate populations and consequent effects on winterkill, (2) annual variation in availability of ungulate carrion, (3) redistribution of carcasses with respect to human facilities, (4) redistribution with respect to forest-nonforest edges, and (5) availability of carrion on large-bodied carcasses, especially adult female bison. Considerable

uncertainty exists over likely effects of reintroduced wolves on spring grizzly bear use of ungulates in the study area.

A Preliminary Assessment of the Non-ungulate Prey Base for Wolves in Yellowstone National Park

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Executive Summary

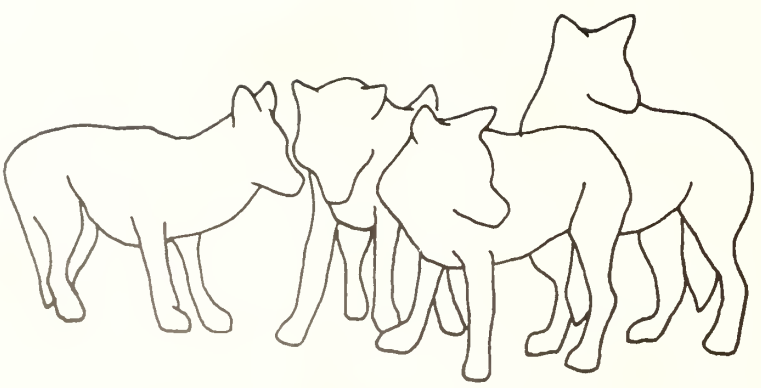
1. Although ungulates comprise a large majority of the wolf diet, non-ungulate mammal prey (shrews to beaver) can be important.

2. Studies indicate that small mammal prey is an important alternative to ungulate prey in the non-winter seasons.

3. Six small mammal prey species present on the Northern Range (primary historic wolf range) were identified as potentially important for wolves: beaver, marmots, ground squirrels, snowshoe hare, pocket gophers, and voles.

4. It is predicted that small mammal prey will comprise only a small portion of the wolf diet on the Northern Range; however, ground squirrels (including marmots), voles and pocket gophers, and snowshoe hare will be important seasonally.

5. Small mammal prey will be utilized by wolves during the spring and late summer months when young ungulates are not as available or vulnerable and when wolves are energetically stressed due to need to provide food for pups.

6. Small mammal prey, or lack of it, could play a significant role in a wolf restoration attempt if there is a relationship between decreased ungulate vulnerability and late summer pup starvation.

7. It is recommended to continue the development of a small mammal prey inventory and monitoring method.